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THE AMERICAN

METEOROLOGICAL JOURNAL.

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THE GEOGRAPHICAL DISTRIBUTION OF THE MAXIMUM AND MINIMUM HOURLY WIND VELOCITIES, AND THEIR RELATIONS TO THE AVERAGE DAILY WIND VELOCITIES FOR JANUARY AND JULY, FOR THE UNITED STATES.

FRANK WALDO, PH.D.

[Published by permission of the proper authorities of the U. S. Weather Bureau of the U. S. Agricultural Department, for whom was written a memoir on the Hourly Wind Velocities in the United States.]

THE material on which this discussion is based is that collected by the U. S. Signal Service and Weather Bureau, and the amounts of wind are given in true miles per hour; the conversion from the usual anemometer miles (with constant 3.00) having been made by means of Marvin's Table, which has already been published by the U. S. Weather Bureau. In my original paper additional charts are given which present the relation shown in a much clearer light than the mainly verbal description which I give here. It must be remarked, also, that the number of separate topics mentioned has necessitated a very brief treatment of each.

The order of treatment is as follows: —

1. Hour of maximum wind.
2. Hour of minimum wind.
3. Maximum hourly wind, miles per hour.
4. Minimum hourly wind, miles per hour.
5. Maximum minus the minimum hourly wind, miles per hour (Range).
6. Maximum hourly wind, divided by the daily average hourly wind (max ÷ av).
7. Minimum hourly wind divided by the daily average hourly wind (min ÷ av).

8. Maximum minus the minimum hourly wind divided by the daily average hourly wind [(max — min) ÷ av].

These separate headings will now be taken up in their order, without stopping to make allusions to the history of the subject of hourly winds as evolved by Hann, Köppen, and others.

1. *Hour of Maximum Wind.*

January. Chart 1. It was hoped that in all cases there would be an interesting field for study in the distribution of the *hour* of maximum wind, but the accompanying chart drawn for January allows no very satisfactory conclusions to be drawn from it. It may be that the few years of observations used in obtaining the average values were not sufficient to determine the hour of maximum wind with the necessary accuracy, and it may be that the local irregularities will not permit the relations of the true conditions to be pointed out.

The early morning maximum occurs on the exposed Atlantic Coast, at from 2h. to 4h.; *i. e.*, shortly after midnight. On the North Pacific Coast there is a retardation to 6h.; but the relative inland conditions do not point to any real differences existing between the times on the western and eastern coasts of the continent. It is a noticeable feature that on the Great Lakes, even for the best exposed stations, there is no apparent influence of the water surface on the *hour* of the maximum. On the Gulf of Mexico, both the eastern and western portions have the same hour, 12 h., and which is two or three hours earlier than that found a short distance inland.

For the *inland* stations the hour of maximum is somewhere about 14h. for nearly the whole of the United States. Deviations from this of one or two hours are frequent, and occur symmetrically for limited groups of stations. The unusually early hour of 10h. is to be noticed on the central part of the Mississippi River, and in the extreme southern part of Arizona 11h. is the time of maximum wind. The late hour of 16h. is also to be noticed for the high lands in the northwestern part of the United States. The distribution of the hour for January does not, as a whole, offer the interesting phases to be found for the midsummer month of July, which we shall now consider.

July. Chart 2. It was to have been expected that the times of maximum wind would be more sharply and strongly

marked at this season of the year than in midwinter, for this has been shown many times, but some peculiarities in the distribution of the time are not wholly in accordance with the views at present accepted by meteorologists. On the coast of the *Atlantic Ocean* (an eastern coast), there is a maximum wind at 14h. in latitude 45°, and the time is retarded with the southward progress until in the latitude of 30° the hour is changed to 18h. For the most exposed coast stations the hour does not differ materially from that of the adjacent land.

On the Pacific coast (a west coast), the time of maximum is nearly the same as for the near inland (perhaps a little earlier) in the central and northern parts, but in the southern part the time is 13h. which is very much earlier than for the adjacent inland or the northern part of the coast. In this same connection attention is called to the great differences existing for the eastern and western parts of the Gulf of Mexico. When there is a western water front as in Florida, the hour is also earlier (12h.), while for Texas, with an eastern water front there is little difference from the hour for the near inland maximum. This seems to be true only for the southern regions, for, on the Great Lakes the hour does not differ from that for the near inland region.

In general, for the inland northeast United States the hour is lowest or earliest (14h.), and there is a retardation with both western and southern progress. There are, however, limited regions where the progression is interrupted ; as, for instance, in Tennessee, Iowa, and Missouri, there is a return to the 14h. maximum. In the Great Plateau region, extending from Arizona to Washington, there is a strip of perhaps 10 degrees in width where there is a return to the 15h. maximum. It is difficult to state any single reason for this increase in the hour of maximum with the western progress, but the nearer approach towards a western coast seems to be accompanied by a real change in the character of the winds, and especially of the vertical wind distribution, since this last would affect the daily maximum of the wind as explained by the Espy-Köppen theory. That the continentality, merely, could not cause much difference is shown by the 15h. maximum in central Kansas, and that the altitude does not have very great effect is shown by the return to 15h. as noticed on the central high plateau.

January. Hour of Minimum Wind. Chart 3. There is a much more uncertain element in the times of minimum, due mainly to the fact that the rate of change is so slight at this time; but partly also to the fact that there is usually a second minimum, and sometimes one is the primary, and again for a neighboring station this hour will be merely a secondary minimum.

In the eastern part of the United States the minimum occurs mainly between 2h. and 7h., except on the central Atlantic coast where it is at 8h. The early evening minimum (18h.) for the high exposures at Atlanta and St. Louis must be noted. The coast exposure seems to be very little different from that of the immediately adjacent mainland, but if there is any real difference there is a retardation of the minimum hour on the ocean. The hour for the Upper Lakes is about the same as for the North Atlantic, but the Lower Lakes have marked irregularities (perhaps due to the peculiar exposures of stations.) The hours for the eastern and western Gulf coasts are about the same (5h. and 6h.), but the northern coast shows a minimum early in the evening (20h.) such as is found there farther inland. There is, perhaps, a tendency on the Atlantic Ocean coast for an earlier hour of minimum with the southward progress.

The early evening minimum (18h.) in the south central part of the United States makes this minimum just the reverse (12 hours apart) of the condition directly north of it, but there seems to be a large central area of the Rocky Mountains and Western Plateau where nearly this same condition prevails (22h.).

These conditions are evidently mainly due to a slight excess in magnitude of the usual depression of the secondary minimum, but this distribution of phases must certainly be studied in connection with the local wind direction in order to find out the causes of the effects noted.

July. Hour of Minimum Wind. Chart 4. This distribution of the hour of minimum daily wind is by no means as satisfactory as that just discussed for the hour of maximum. On the Atlantic coast there is probably a retardation with southward progress, but on the Pacific coast the opposite seems to be true. The hours on the coast do not differ much from the near inland, except on the western exposure of coast in Florida and southern

California, where an earlier hour of minimum occurs. On the eastern coast of the Gulf of Mexico the minimum occurs in the neighborhood of midnight, but on the western coast shortly before sunrise.

In the Lake Region there are considerable irregularities in the time of minimum, evidently due to the exposures of the stations, but the average time would probably be at about 0 hours (midnight). There is a retardation towards the south and west to an average time of about 5h. However, in the Lower Mississippi and Arkansas River valleys, there is a local return to an earlier hour, near midnight; and in the central plateau region (Utah, etc.), the late hour of 7 is the time of minimum. The results from the elevated anemometers at St. Louis and Atlanta do not differ much from those from lower ones near by. The most widely distributed hour is about the 5th.

January. Maximum Hourly Wind. Miles per hour. The distribution of this data is shown on Chart 5. On the North Atlantic and North Pacific coasts the wind reaches a velocity of seventeen miles per hour in both cases. The amount decreases with southward progress, but on the central coasts the wind velocities on the Pacific Ocean seem to be considerably in excess of those on the Atlantic; further south, however, on the southeast and southwest coasts of the United States, the Atlantic winds appear to be the stronger.

The eastern and western Gulf coasts have about the same maximum velocities of 12 miles per hour. The velocities on the Great Lakes are probably fully equal to the amounts for the ocean coasts on the same parallel east and west of them, although the best lake exposures give but 14 miles per hour of wind.

The inland distribution shows a maximum of 10 to 13 miles per hour for the Great Plains. In the southeast United States a maximum of 7 miles per hour occurs, while in the northwest United States a maximum of only 4 or 5 miles per hour is to be found. In the southwest United States, however, an abnormally high wind velocity (9) is maintained (except in Arizona, Phœnix). This is a peculiarity of this region, the study of which will prove of great interest. It is noticeable that stations of extra high anemometer exposure, such as Atlanta and St. Louis, show abnormally high velocities.

July. Maximum Hourly Wind. Miles per hour. Chart 6. The chart showing the distribution of the maximum amount of wind in the midsummer month is of especial interest, as it is in a degree a measure of the vertical atmospheric disturbances caused by the heating up of the earth (and the nearest air layers) by the maximum heat derived from the solar rays.

On the exposed Atlantic coast there is a slight decrease in the wind from the New England coast (13) to the Carolina coast (11); but for the more nearly land exposures there seems to be little difference. For the Lakes the amount is probably about the same as for the north Atlantic coast. The eastern Gulf coast and probably also the central coast is somewhat lower than was expected (8.5) and coincides nearly with the poorer exposures on the southern Atlantic coast; but on the western Gulf coast (Texas), the enormous velocity of over 15 miles per hour is to be found. With one exception this is the highest velocity reached by an ordinary exposure.

On the north Pacific coast there is a surprisingly small maximum amount of wind (8), but on the central California coast (San Francisco) this surprise is counterbalanced by the enormous velocity of 18 miles per hour (nearly as much as at Cape Mendocino, 21.5). It would be interesting to examine more minutely the local characteristics of this wind, which we can only compare with the high tide water of the Bay of Fundy or that on some of the British coasts. One is reminded of the description of the daily change in wind on the Chilian coast, as given by Hann in his "*Klimatologie.*" On the south Pacific coast the wind velocity is also abnormally large (11).

Inland on the Great Plains the maximum wind is about 10 or 11 miles per hour, for most of the distance across the United States from north to south, except in Kansas where it reaches 13.5. There is then a decrease to 8 in the northern Mississippi Valley, and to 6 in the southern Mississippi Valley, with a dividing line along the Ohio River Valley. North of this line the velocities are about 8, and south of it from 5 to 7 miles per hour. At Atlanta and St. Louis (high exposure anemometers) the velocities are but little above those for neighboring stations.

West of the Great Plains, in the Rocky Mountain region, a velocity of 9 is reached. On the north, the Great Plateau

has low values of 6 and 7, while in the central and southern parts the velocities are high (9 and 10).

In the extreme southwest the very high velocities of 12 at Prescott and nearly 10 at Yuma are special features. In Central California and the valleys of the western slope, the maximum velocities are about 8 miles per hour.

January Minimum Hourly Wind. Miles per hour. Chart 7. On the northern coasts of the Atlantic and Pacific Ocean, the minimum velocities are nearly the same, a little over 15 miles per hour, but they decrease with the latitude. On the central coasts, however, the winds on the Atlantic coast far exceed those of the Pacific; while on the southern coasts the Atlantic (5) is slightly in excess of the Pacific (4).

The winds on the eastern and western Gulf coasts are about the same (10), and are a little less than on the Great Lakes where a velocity of 13 miles per hour is retained for the best exposure. The northern part of the Great Plains has but 6 miles per hour of wind, while in the southern part a velocity of 10 is maintained. The northern plateau has but 3 or 4 miles per hour of wind, and the southwestern part of the United States even less. In most of the inland region east of the Mississippi River, a wind velocity of from 5 to 7 miles an hour prevails.

July. Minimum Hourly Wind. Miles per hour. Chart 8. On the exposed Atlantic coast there is, perhaps, a slight decrease from New England (10) to Carolina (8), but as the same values (5) are found in Maine and Georgia for low city exposures, there is probably little real difference in similar land exposures along the whole Atlantic seaboard. On the Lakes and both eastern and western Gulf coasts a minimum of 6 miles per hour is found. For the Pacific coast low velocities are the rule, the exposed stations in the north showing but 6, San Francisco but 7, and ordinary exposures in Southern California but 3 miles per hour of wind.

Inland there is a decrease of velocities to from 5 to 7 (and in Central Kansas 8) on the Great Plains, to 4 in the Mississippi River Valley, and to 3 south and east of the Ohio and Mississippi Rivers. At Atlanta and St. Louis the velocities are about double those of neighboring low exposures.

West of the Great Plains there is a rapid falling off (except

for very high exposed stations) with westward progress, and in most of the Great Plateau region velocities of 2 and 3 miles per hour are prevalent from the northern to the southern boundary. In the valleys of the western slope the velocities range from 1 to 4 miles per hour, being greatest in the south. The great magnitude of some of the oscillations are brought out so clearly by the chart of differences that more does not need to be said about it at this place.

January. (*Maximum — Minimum*) *Hourly Wind. Miles per hour.* (*Range.*) Chart 9. This chart must be studied in connection with charts of maximum and minimum winds in order to bring out clearly the significance of the numbers which show in miles per hour the daily range for this month. The regions of least absolute range are the exposed Atlantic coast, certain exposures on the Lakes, the lower Mississippi Valley, and the extreme northwest United States inland; the windiest hour of the day exceeding the calmest by but 1.0 mile per hour.

It is noteworthy that most of the Lake stations, the eastern and western and probably central Gulf stations, and the northwest coast (Pacific) stations furnish records of about 2.0 miles per hour range in the wind velocity. Some of the best exposed Lake stations show differences of even 3.0. A range of from 2.0 to 3.0 is most common in the eastern half of the United States, the influence of the water ceasing very soon after leaving the coast. The exceptionally low differences in portions of the Mississippi Valley may be due to the flow of air between the steep river banks, by which means the direction deviates from the true one, and the changes in velocity are in a measure regulated. It is also to be noticed that the high exposed anemometers at Atlanta and St. Louis do not record differences which depart much from those of adjoining stations. There is a steady increase towards the southwest United States, both with the northern and eastern approach. The great range of 6.0 miles per hour in southern Arizona is probably by no means so local a matter as it might at first appear to be, for a range of 5.0 is found on the California coast near by. Just how far northward along the Pacific coast this extreme range continues to exist it is impossible to say from the data at hand, but at Cape Mendocino the very large difference of nearly eight miles

per hour is to be found at an altitude of several hundred feet above sea level. In order to make a careful study of this whole matter of change of wind velocity, from hour to hour, it is absolutely necessary to take account of the wind direction, the land and water distribution, and the configuration of the land surface.

July. (*Maximum — Minimum*) *Hourly Wind. Miles per hour.* (*Range.*) Chart 10. The distribution of the absolute range in miles per hour for the month of highest temperature is of extreme interest. For the entire portion of the United States east of about the 95th meridian, and south of the Great Lakes, the average or normal range of the wind is about 4 miles per hour. On the lower Mississippi River for a limited region it decreases to 3 miles per hour, and on the central Ohio River it increases to 5 miles per hour. For the high exposure at Atlanta and the low exposure at Charlotte the range is but 2 miles per hour. On the Atlantic coast the range is 3 miles per hour for the exposed stations (consequently little below that of the land), and it is probably about the same (3) along the Canadian border and upper parts of the Great Lakes. On these latter the water exposure seems to cause the range to differ very little from that for land exposure.

The Gulf of Mexico has a range of only 2 on the eastern part, which is probably not more than half what it would be for a land exposure there; while on the northern shores the range is 4 miles per hour, which is the same as for the inland. In the western part, however, the range is enormous, reaching 10 miles per hour at Corpus Christi.

On the Great Plains the range is 4 and 5 miles per hour, but in eastern Texas the very low range of 2 miles per hour is found for an apparently good exposure.

West of the 105th meridian on the Great Plateau the range is 3 miles per hour in the north, increasing rapidly to 5 which is *probably* maintained to about the southern limits of Utah and Colorado; but great irregularities exist in the extreme southern portion, where 6 miles per hour is about the usual range, although at Prescott it reaches 10 miles per hour. However, at Phoenix and El Paso it is only 3 and 2 respectively.

On the Pacific coast, in the northern part, the range is 2.5 miles per hour, which is slightly less than on the Atlantic coast,

but at San Francisco there exists the enormous range of 11 miles per hour (although at Cape Mendocino it is but 6), and in southern California it is 8 miles per hour. The complicated effects of the land and sea breeze, coast contour, coast mountain ranges, and monsoon winds need to be studied in order to arrive at any satisfactory explanation of these great changes in the wind velocities during the day. On the Pacific slope inland for the central portion 4 miles per hour is about the average range, although in western Oregon it seems to be more nearly that observed at Cape Mendocino.

January. Maximum Hourly Wind Divided by the Daily Average Hourly Wind (*Max ÷ Av*). Chart 11. In the month of January for most of the United States the maximum wind does not greatly exceed the average, and so the ratios are not excessive. For the exposed Atlantic coast a ratio of 1.05 in the northern part becomes slightly less (1.02) in the central part, but when the land influence is felt a ratio of 1.05 for the northern region increases with progress southward to 1.30 on the southern coast. On the Gulf of Mexico the ratio is generally 1.10, but in the extreme western part is probably slightly greater; and this same ratio of 1.10 likewise holds good in the main for the Great Lakes, although on the eastern shore of Lake Erie it becomes 1.15. On the Pacific coast the ratio for the exposed coast in the north is 1.05, and this increases with the southward progress much more rapidly than on the Atlantic, becoming 1.25 at San Francisco and 1.65 in southern California.

Inland for most of the Great Plains and extending well up the slope of the Great Plateau, the ratio is 1.20, but with an interior limited maximum of 1.30 on the central Great Plains. To the eastward of this there is a decrease toward the Mississippi Valley where for a narrow region of the lower Mississippi there is a ratio of but 1.10, and then there is an increase of 1.20 for the eastern inland United States, and a still further increase to 1.30 along the Atlantic slope. West of the region of 1.20 on the Great Plains, there is a decrease to 1.05 in the extreme north, a slight increase to 1.30 for the central plateau, and a rapid increase to 1.70 for Central Arizona, but along the southwest boundary of the United States the ratio is probably 1.35. For the high exposures of anemometers the ratios are: Winnemucca, 1.10, Fort Assiniboine, 1.05, Atlanta, 1.05, and St. Louis, 1.03,

and these, it will be observed, are about the same as for the exposed seacoast stations.

July. Maximum Hourly Wind Divided by the Daily Average Hourly Wind (*max* + *av*). Chart 12. These ratios are, for the Atlantic coast, 1.05 for the exposed stations in the northern part, but with an increase to 1.20 in the central portion; but when the land influence is more strongly felt there seems to be little difference, the ratio all along the coast ranging between 1.30 and 1.40. On the coasts of the Gulf of Mexico the eastern part has a ratio of 1.15, and this increases to 1.25 in the northwestern, and still further to 1.40 in the western portions. On the Great Lakes a common ratio of 1.30 obtains. For the Pacific coast a ratio of 1.15 for best exposures in the northern part increases to 1.55 for the central, and to 1.85 for the southern portions, but with more of the land exposure.

Inland, for the Great Plains and eastern slope of the plateau, the ratio is 1.35 in the north, 1.30 at the centre, and 1.20 at the south; consequently, there is here a decrease towards the south. For the immediate Mississippi River valley the ratio is 1.45 in the north and 1.30 at the centre and in the south. On the lower Arkansas River there is a limited region with a ratio of 1.50, but on the Ohio River system and extending eastward into Virginia there is a region of 1.50 containing isolated maxima of 1.60. To the westward of about the 110th meridian the ratio at first increases. For the greater part of the central region of the Great Plateau, and extending from north to south the entire length, the ratio is 1.50, but with a maximum of 1.70 in central Arizona. Along the Pacific slope the ratio decreases again to between 1.30 and 1.40. The high exposures at Fort Assiniboine, St. Louis, and Atlanta (especially the last) have ratios considerably smaller than for neighboring low exposures.

January. Minimum Hourly Wind Divided by the Daily Average Hourly Wind (*Min* + *Av*). Chart 13. For the exposed stations of the Atlantic coast a ratio of .96 on the northern and .97 on the central coast shows no indication of marked change with the latitude; nor is this to be noticed for the stations with better land exposures, for the .90 ratio is found from the Massachusetts to the Georgia coast. For the Gulf of Mexico the ratio is .90, and the same holds good for the Great Lakes except on the extreme Lower Lakes, where it increases to .95. On the

Pacific coast a ratio of .93 in the extreme north (good sea exposure), becomes .80 on the central coast and decreases to .70 in the extreme south.

Inland, the ratio of .90 covers the entire country extending from a line drawn from northern Montana to southern Texas, eastward to within a few hundred miles of the Appalachian Mountains, where it becomes lower and reaches a minimum on the eastern slope of those mountains and their foothills from Virginia to Massachusetts. To the west of the limits of this .90 region there is scarcely any change in the northern region westward to the Pacific coast, but in the central part there is a probable slight diminution to .80, with a local increase to .90; and towards the southwest United States there is a decrease to .65 in the central part of Arizona and southern California. Along the southwest boundary of the United States the ratio is .70 in the western and .80 in the eastern portion. It is to be noticed that the ratios for the high exposed anemometers (St. Louis, Atlanta, etc.) do not differ materially from those of surrounding lower stations.

July. Minimum Hourly Wind Divided by the Daily Average Hourly Wind (*Min* ÷ *Av*). Chart 14. On the Atlantic coast the ratios for the exposed stations are .90 in the northern and .85 in the central portions; and this slight decrease with latitude is also shown for the more nearly land exposures where a ratio of .80 in the north becomes .70 in the south. On the Gulf coast the ratio of .85 in the eastern part decreases to nearly .70 in the northwestern and to but .45 in the extreme western part. For the Great Lakes the ratios are in the main about .80. On the Pacific coast the ratio of .85 in the north (water exposure) decreases to .60 for the central and .50 for the southern portions.

Inland, on the Great Plains, a ratio of .75 in the northern part decreases to .70 in the central and increases to .80 in the southern portions; but decreases again in the extreme south. To the eastward of the 97th meridian the ratio is from .60 to .70, the lesser ratio being found in the lower Missouri and Arkansas River Valleys and those of the Ohio River System. For the central Mississippi Valley, however, there is a ratio of .80. To the westward of about the 107th meridian there is a decrease such that the ratios for the Great Plateau are between .50 and

.60, but at Prescott, in central Arizona, it decreases to .30. The ratios for the high exposures at Fort Assiniboine, Winnemucca, and Atlanta, are considerably higher than for the neighboring low stations, but at St. Louis the ratio is but slightly higher than for the neighboring Mississippi Valley stations, although much more than for other adjoining regions.

January. Maximum minus the Minimum Hourly Wind Divided by the Daily Average Hourly Wind ([*Max* — *Min*] ÷ *Av*). Chart 15. The range of the hourly wind velocities expressed in terms of the average hourly wind velocity for this midwinter month are as follows: on the Atlantic coast for the exposed stations the range is .08 in the northern and slightly less .05 in the central portions, but when the land influence is felt the range increases from .10 in the extreme north to .40 in the south, with an abnormal range of .70 at Jacksonville, Fla. On the Gulf coast the range of .17 in the eastern and northwestern portions increases to .25 in the extreme western part. On the Great Lakes the range is .20 in the western part, about .25 in the central or southern, and .10 in the eastern portions. On the Pacific coast a range of .10 for the exposed stations in the north increases to .45 at the central region and to .95 in the extreme south; but always for these last mentioned sections there is more of a land exposure.

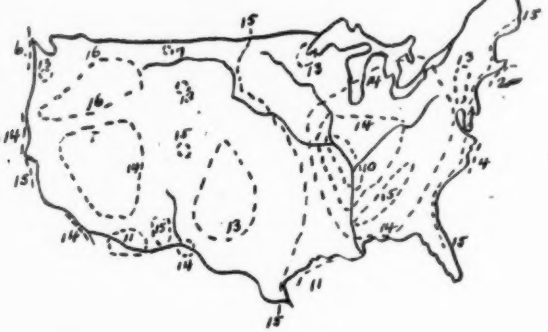
Inland for most of the Great Plains, the range is .30 but with a local central increase to .40 at about the latitude of 40°. To the eastward of this region there is a decrease in the northern portion toward the Great Lakes, and in the southern portion a decrease to .20 in the Mississippi and Lower Ohio River valleys, and then a gradual increase until the maximum of .40 near the coast is reached; but from central Virginia to western Massachusetts there seems to be a narrow region with a local maximum of .50. To the westward of the central .30 region, about the 105th meridian, there is a decrease to .20 in the extreme north, an increase to .50 for the centre of the Great Plateau, and an increase to nearly 1.00 in the southwest United States; but for the greater part of the southwest boundary of the United States the ratio probably does not exceed .60. The increase of ratios with decrease of latitude noticed on the Pacific coast is therefore as strongly marked for the whole Great Plateau region. For the high exposures of anemometers at Winnemucca, .20, and

Atlanta, .15, the ratios are much less than for the surrounding low exposures; while at St. Louis, .10, the ratios are also considerably less than elsewhere in the Mississippi Valley.

July. Maximum Minus the Minimum Hourly Winds Divided by the Daily Average Hourly Winds ([*Max* — *Min*] + *Av*). Chart 16. On the Atlantic coast for the exposed stations in the northern part, the range in terms of the average is .27, and this increases slightly to .35 in the central part; and, too, when the land influence is felt more strongly the increase from .50 in the northern portion to .70 in the southern shows a like change. On the Gulf coast the range is .30 in the eastern part with an increase to .40 in the northwestern, and apparently to .95 in the extreme western portions. On the Great Lakes a range of probably .40 in the most northerly portions becomes .55 in the southern. On the Pacific coast a range of .32 in the extreme north (sea exposure) increases to .95 at the central region (San Francisco) and suffers a still further increase to 1.35 in the extreme south. But at the high station of Cape Mendocino the range differs little from that much further north at sea level.

Inland, on the higher Great Plains, the range in terms of the average is about .60 in the northern, .50 in the central, and but .40 in the extreme southern portions. East of this there is little change in the direction of the Great Lakes, but a little south of them a marked increase. Along the 95th meridian in western Missouri there is probably a limited region of .90, but a little further eastward, along the central Mississippi River, the range is but .50. In general the range is .70 southeast of the Ohio-Mississippi River system, and extending nearly or quite to the coast; but between the Ohio and Tennessee rivers and extending eastward into Virginia there is a region of much greater range, perhaps about .90, but in isolated cases reaching 1.10 and 1.15. The high exposures at Winnemucca, Fort Assiniboin, and Atlanta have a relative range of only one half or one third of that for surrounding low exposures, and the same is true for St. Louis when the region to the east and the west are considered, but there is but a slight deficiency when compared with the neighboring stations on the Mississippi River. It may be that the north-southerly water (river) exposure gives a less range than the east-westerly exposures common to the tributaries of the central Mississippi River. The decrease with the latitude

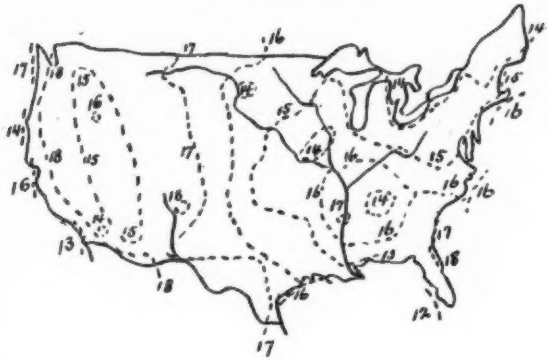
1. Hour of Max. Wind. January.



3. Hour of Min. Wind. January.

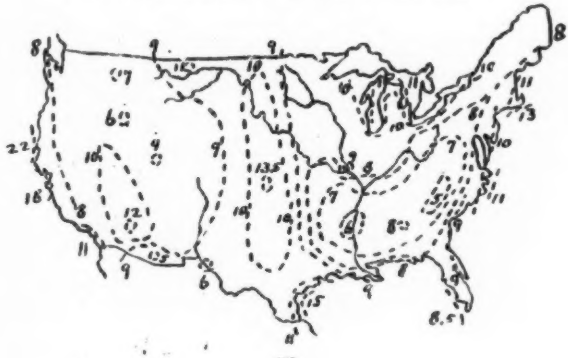
5. Max. Hourly Wind (miles per hour). January.

2. Hour of Max. Wind. July.



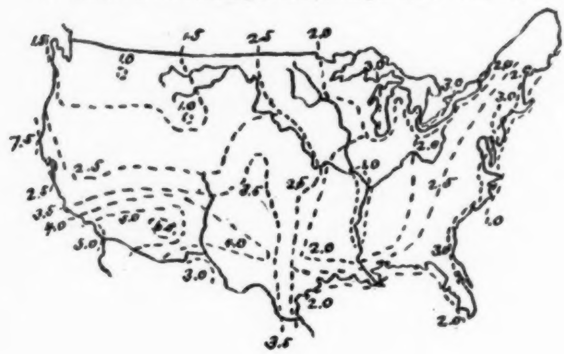
4. Hour of Min. Wind. July.

6. Max. Hourly Wind (miles per hour). July.

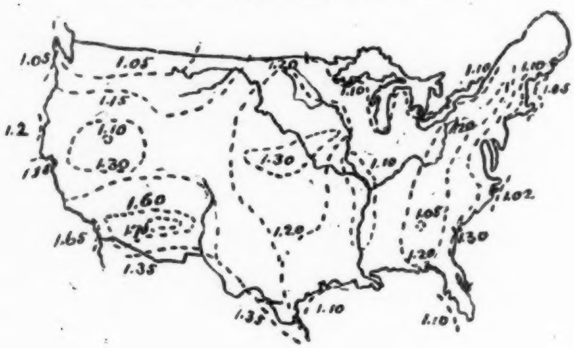


7. Min. Hourly Wind (miles per hour). January.

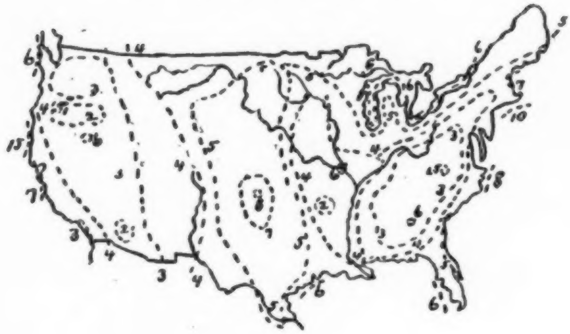
9. Max. less Min. Hourly Wind (miles per hour). January.



11. Max ÷ Average Hourly Wind. January.

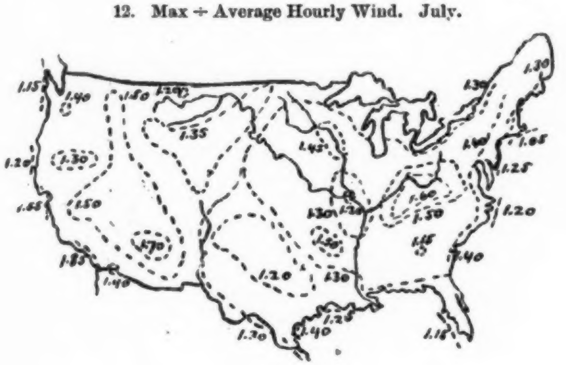


8. Min. Hourly Wind (miles per hour). July.



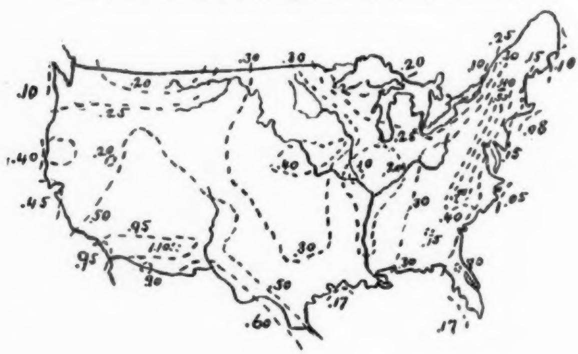
10. Max. less Min. Hourly Wind (miles per hour). July.

12. Max ÷ Average Hourly Wind. July.



13. Min. ÷ Average Hourly Wind. January.

15. (Max − Min) ÷ (Average Hourly Wind). January.



14. Min. ÷ Average Hourly Wind. July.

16. (Max — Min) ÷ Average Hourly Wind. July.

on the Great-Plains at the interior of the continent is a *reversal* of the conditions prevailing nearer and on the coasts, and this same feature is noticeable on a number of the charts given in this investigation. In the present case it is mainly due to the conditions represented on the map showing the excess of the maximum winds, rather than the deficiency of the minimum wind. In *January* a more neutral condition prevails in the interior region, but for the whole *year* there is a fairly well-marked condition such as has just been pointed out for July.

PRINCETON, NEW JERSEY.

CURRENT NOTES.

Studies of the Upper Air.—Mr. A. Lawrence Rotch, of Blue Hill Observatory, Readville, Mass., read a paper entitled *Studies of the Upper Air: The Methods Employed and the Results Obtained*, before the Boston Scientific Society on March 26, 1895. This paper was printed in the Boston *Commonwealth* for April 6, 1895, and has been reprinted in pamphlet form. A summary of Mr. Rotch's address follows:—

Meteorology is concerned with that portion of the atmosphere within ten miles of the earth, which embraces eight-ninths of the mass of the whole. Into this atmosphere man has seldom penetrated above four miles, the chief obstacle to a lofty ascent being the rarefaction of the air, whose pressure at a height of ten miles is less than one-ninth of the pressure at sea level. A height of about 30,000 feet has been twice reached by men, in balloons, during the past 33 years, and an altitude of nearly 23,000 feet has been reached in the Himalayas, and records of pressure and temperature were obtained in each case. Recently, automatic instruments, recording pressure and temperature, have been sent up in small balloons carrying no aeronauts, in France and Germany, and a height of about ten miles has twice been reached. The establishment of self-recording instruments on the summit of El Misti, in Peru, at a height of 19,300 feet, will, it is hoped, give fairly continuous records from that elevation.

The importance of observations of the meteorological elements in the upper air, away from the influence of the earth's surface, is now generally recognized, and this has led to the erection of a large number of mountain observatories in the different countries. The first summit station in the world was established on Mt. Washington, N. H., 6,280 feet, jointly by the United States Signal Service and Prof. J. H. Huntington, in 1870. Very severe weather has been experienced at this station, the lowest temperatures there being often accompanied by very violent winds, as, for instance, in February, 1886, when a temperature of 50° below zero was registered during a gale of 184 miles an hour. The Pike's Peak station, 14,134 feet, was for many years the highest in the world, but as both the Pike's Peak and Mt. Washington stations are now closed, there are only two summit stations in the United States where meteorological observations are regularly made throughout the year. These are the Lick Observatory, on Mt. Hamilton, Cal., which is primarily an astronomical observatory, and Blue Hill Observatory, in Massachusetts. Mt. Whitney, in California, 14,500 feet, was the station at which Prof. S. P. Langley made his important researches on solar heat in 1881.

In Peru the Harvard College Observatory has now established the highest meteorological station in the world, 19,300 feet, on the summit of El

Misti (see this JOURNAL, Vol. X., 433, 434). The point previously occupied, on Mt. Chachani, 16,650 feet (see this JOURNAL, Vol. X., 282–287), has been abandoned. The Misti station is visited by one of the observatory staff several times a month, when the clocks of the instruments are wound, the register sheets changed, and check readings of standard instruments made.

In France immense sums of money have been spent in building and maintaining summit stations, and a splendid chain of such stations now exists on the Puy de Dôme (4,800 feet), the Pic du Midi (9,440 feet), Mont Ventoux (6,250 feet), and the Aigonal (5,150 feet), these being situated in Auvergne, the Pyrenees, Provence, and the Cevennes, respectively. M. Vallot has established several stations on and near Mont Blanc, and records have been obtained from them each summer since 1890. The highest of these stations at the Rochers des Bosses, 14,320 feet, is provided with self-recording instruments that run two weeks without attention, and are looked after by the owner or his guides during the summer. (See this JOURNAL, Vol. IX., 411–414).

M. Janssen's Observatory on Mont Blanc 1,460 feet higher than the Rochers des Bosses, is not yet in operation. A meteorograph has been made for it by Richard Frères, of Paris, which will run three months without attention (see this JOURNAL, Vol. XI., 392). On the Eiffel Tower, in Paris, self-recording instruments are placed at a height of 980 feet above the ground, and these give the conditions prevailing in the free air more nearly than do any others permanently at this elevation.

In Austria the Sonnblick station, at an elevation of 10,170 feet in the Austrian Alps, is the highest observatory in Europe which is permanently occupied. This station has given meteorology some very valuable results.

Switzerland has one of the best located and best equipped mountain stations in the world on the Säntis, 8,200 feet, in the Canton of Appenzell, and Italy has recently completed an observatory on Monte Cimone, 7,100 feet, in the Apennines, near Lucca. In Great Britain the Ben Nevis station, 4,400 feet, has given a series of ten years of unbroken hourly observations, and these valuable records, together with those obtained at the base station, have been ably discussed by Dr. Buchan.

The fact that meteorological conditions on mountains do not exactly correspond to those prevailing in the free air, and the desire to reach a great height have led to the employment of balloons in meteorology, especially within the last year or two. The first scientific balloon ascent was made by Dr. John Jeffries, of Boston, Mass., in 1784, from London (see this JOURNAL, Vol. IX., 58–63). Other ascents were those of Gay Lussac, 1804, who reached 23,000 feet, of Barral and Bixio in 1850, and of Welsh in 1852, who reached nearly the same altitude. Coxwell and Glaisher, in 1862, made their famous ascent, in which both aeronauts became unconscious at 29,000 feet, and in 1877 Crocé-Spinelli, Sivel, and Tissandier reached nearly the same height, when the two former were asphyxiated.

Within the last few years numerous scientific balloon ascents have been made, the observations made on these ascents having been much more trustworthy than the older ones were, owing to the use of the aspiration

psychrometer, invented by Dr. Assmann of Berlin. By this instrument a current of air is drawn past the bulbs of the wet and dry bulb thermometers, so that the true free air conditions are obtained, and further, the thermometers are enclosed in polished metal tubes to cut off the direct solar or reflected heat rays. The most notable ascent of recent years, if not of all time, is that of Dr. Berson, who last year reached perhaps the highest point ever attained by man. His barometer read 9.1 inches, which corresponds to an elevation of approximately 30,000 feet. At this height of nearly 6 miles, the aspirated thermometer read —54° Fahr., and one exposed to the sun's rays —11° Fahr. Dr. Berson inhaled oxygen from time to time, and suffered little from the diminished pressure. Among the chief results of Dr. Berson's observations may be mentioned the discovery of a much more rapid decrease of temperature between 1 and 6 miles than has been assumed for winter; the feeble insolation, the great humidity of the upper strata, and the fine haze which extended up at least 6 miles; the snow-flake structure of the cirro-stratus clouds, which were formerly considered to be composed of ice crystals; the great increase of wind-velocity, from nearly a calm at the earth's surface to 36 miles an hour at the average elevation of the balloon.

Self-recording instruments have been sent up in small balloons carrying no aeronaut, and in two cases have brought down very valuable results. In France, M. Hermite sent up a balloon called *L'Aérophile*, which reached a probable height of ten miles (see this JOURNAL, Vol. X., pp. 423–427), and in Germany the *Cirrus* reached a height of over ten miles last July (see this JOURNAL, Vol. XI., pp. 340–341).

The use of kites for taking up meteorological instruments was first adopted by Mr. E. Douglas Archibald, in England, who sent up anemometers attached to kites flown in series, and attained a considerable altitude. In this country Mr. W. A. Eddy has made numerous experiments with Malay, or tailless kites, flown tandem, and during the summer of 1894, at Blue Hill Observatory, some interesting results were obtained (see this JOURNAL, Vol. XI., pp. 297–303).

Observations of the velocity and movement of clouds have been made at various observatories, and in this way the motions of the upper air currents may be studied. By means of the telescope, also, the study of atmospheric currents has been carried out to some extent by Montigny and Ventosa, in Europe, and recently by Douglass, of the Lowell Observatory, in Arizona (see Mr. Douglass' paper in this JOURNAL, Vol. XI., pp. 395–413).

The concluding paragraph of Mr. Rotch's paper is as follows: "In closing this review of the various methods available for the study of the upper air, it will be seen that observations on mountains are still the only ones capable of being made of all the elements at all times, although clouds can be observed very often, and their systematic study will eventually be recognized as necessary for weather forecasting. Occasionally, observations in captive balloons and with kites will furnish reliable data in special cases when it is desired to investigate the conditions prevailing in the free air near the earth, but the necessarily infrequent observations which can be made at high altitudes in balloons carrying aeronauts, or the few automatic records obtained from unmanned balloons, which may reach still greater

altitudes, will hardly do more than elucidate the general conditions reigning towards the top of the great aerial ocean."

Mr. Rotch's paper is illustrated by a cut showing the comparative altitudes of the various forms of clouds, of some of the principal high level observatories, and of some notable balloon ascents.

Sensible Temperatures. — It is a well-known fact that a dry cold and a dry heat can be much more easily borne than damp cold or heat, and that, for this reason, the intense cold of the interior of Siberia in winter is not as hard to endure as a considerably less degree of cold which is associated with a damp atmosphere. In connection with this subject, which is an especially important one from a climatic and a medical standpoint, Prof. Mark W. Harrington, Chief of the Weather Bureau, read a paper on *Sensible Temperatures* before the American Climatological Association, in Washington, in May, 1894, which has lately been published in pamphlet form.

"By 'sensible' temperature," says the author, "is meant that which is felt at the surface of the skin, where the skin is exposed, as on the face and hands. This may be a very different temperature from that of direct insolation or from that of shade, the two temperatures most discussed by meteorologists. On sensible temperatures depends our sense of comfort in hot weather. They are, therefore, of importance to everyone, but of especial importance to invalids and to their medical advisers." Sensible temperatures depend on evaporation, and, when evaporation takes place, are lower than the shade temperatures given in meteorological tables. When water is changed from the liquid to the vapor condition, a certain quantity of heat is utilized, which, on evaporization, is changed to latent heat and is then no longer sensible. A feeling of coldness, therefore, results from the change, and as long as evaporation continues, the surface where it takes place is cooler than the general temperature of the surrounding air. The degree to which the temperature is reduced by evaporation depends, of course, on the rapidity with which the evaporation takes place, and this depends on the amount of moisture already in the air. If the air happens to be supersaturated, its shade temperature being then lower than the dew point, condensation takes place, and instead of having some sensible heat rendered latent, the reverse process takes place, condensation sets in, and some of the heat which was before latent becomes sensible, and the air temperature is thereby raised.

On the other hand, in cases where the air is not saturated, its shade temperature is above its dew point, and the temperature is reduced, the amount of this reduction depending on the depression of the dew point below the shade temperature.

The general relation of shade temperature, dew point, and relative humidity may be expressed as follows: "The greater the depression of the dew point the less the relative humidity, the drier the air, the more rapid the evaporation, and the greater the reduction of temperature caused by evaporation." Prof. Harrington has prepared a chart to illustrate these features graphically, and by referring to it, the reduction of the shade tem-

perature by evaporation, with varying dew points, can be seen at a glance. The amount of this reduction is greatest where the air is driest, and least where it is moist.

A marked example of the reduction of shade temperature is given as having been noted at Furnace Creek, Death Valley, California, in the summer of 1891. On five days the maximum temperature was 122°, but the dew point was from 44° to 55° and the temperatures of evaporation (obtained by a wet-bulb thermometer) ranged from 74° to 77°. The temperature felt by a person in a favorable situation was from 45° to 48° lower than that registered by the shade thermometer, and was almost cool for a summer afternoon. On Aug. 4 and 5, 1891, the maxima were 118° and 114°; the dew points 30° and 27°; the reduction 48° and 47°, and the temperatures of free evaporation 70° and 67°.

In order to show the effect of this reduction on the temperatures of the United States in July, the author has prepared two charts, one giving the reduction of the mean temperature over the country due to evaporation, and the other, the resulting sensible temperatures. The first chart shows that the reduction varies from 3.5° at Eastport, to over 20° in the southwest. It is 10° to 20° over the plains and Rocky Mountains, from 5° to 10° over the Eastern States and the region about the 100th meridian, and less than 5° in the vicinity of Lake Superior and northeastern New England. Along the Pacific Coast, from the vicinity of Puget Sound to that of Los Angeles, it is less than 5°. As a whole, then, the reduction in the far West is very great, along the Atlantic Coast quite small.

The second chart, giving the actual resulting sensible temperatures, shows that the temperatures really felt in the dry West and Southwest are decidedly lower than the corresponding temperatures in the Eastern States. As an example it may be noted that the sensible temperatures at El Paso, in western Texas, are nearly identical with those at Erie, Pa., on Lake Erie. The sensible temperatures over southern New Mexico and Arizona are closely the same as those of Pennsylvania, southern New York, and Massachusetts, during the hottest season of the year. The highest sensible temperatures in July are found along the Gulf of Mexico and the southern Atlantic Coast. The region of least sensible temperatures is west of the Continental Divide for the most part, and north of Arizona and New Mexico, covering the States of Nevada, Idaho, Montana, a large part of Wyoming and Colorado, and Utah, and reaching the Pacific Coast in northern California, about Cape Mendocino. A small area of higher sensible temperatures appears about Great Salt Lake, owing to the higher degree of relative humidity there, due to the evaporation from the lake.

The concluding paragraph of Prof. Harrington's valuable paper is as follows: "To obtain the beneficial effects of the reduction of temperature by evaporation the shade must be sought and the direct sun's rays avoided. The effects may be heightened by a natural or artificial breeze or wind, and for parts of the body covered by clothing they may be obtained by adapting the clothing to the free passage of air and moisture. For hot weather and in the shade the color of the clothing is of less consequence than its texture, together with sufficient looseness to permit of the free access of air.

The reduction of temperature by evaporation may be increased by many devices for making an artificial breeze (as the fan or the punka) and by offering more water for evaporation, as by a fountain or the dripping screens used in some parts of India."

Central American Rainfall. — There has recently been published, in the *Bulletin of the Philosophical Society of Washington* (Vol. XIII., pages 1–30), a notable report on the rainfall of Central America, the author being Prof. Mark W. Harrington, Chief of the Weather Bureau. The best series of rainfall observations in Central America is that for San José, Costa Rica, at which station the records have been kept for a long time and are now made in accordance with the general plan adopted at first order stations *i. e.*, automatically, and the results are published *in extenso*. A fifteen years' series of records exists for Rivas, on the western shore of Lake Nicaragua, the observer there being Dr. Earl Flint. At San José the observatory is under the direction of Prof. Enrique Pittier. Other records available have been those kept along the course of the Panama canal, at Guatemala City, Belize, San Salvador, and other places.

Central America is a narrow, irregular land surface, extending through 10° of latitude (from 8° N. to 18° N.,) and is 1,200 miles long by from 30 to 300 miles broad. The average width is 150 miles. A ridge of mountains runs through the country, usually less than 10,000 feet high, and for half of its extent less than 6,000 feet. These mountains sometimes descend to moderate hills and at others expand to form extensive plateaus of 3,000 feet or more in height. The coasts have along a considerable part of their extent areas but little above sea level, marked by lagoons and floods.

There are four climatic zones, which are well marked. The lowest is the hot zone, which is found along the coast and to elevations of 300 to 400 feet. This is hot, humid, marshy, and malarial, and is the home of the banana. The second of the four zones extends up to 3,500 feet, is warm, moderately well watered, and is the zone in which the coffee tree and pine-apple are found. The third is cool and rather dry, is the region where the cereals and fruits of the temperate zone are found as well as, in its lower altitudes, the sugar cane and cotton. The second and third zones, together, constitute the *tierra templada*, and are the most thickly populated and most healthy. The fourth zone is above 7,500 feet. Its precipitation is small, frosts are common, and snow is not rare.

As a whole the rainfall is tropical, following the sun north and south of the equator, and giving a dry season when he is south, a wet season when he is north. The maximum rainfall comes when the sun is in the zenith at the place of observation, so that there are two rainy seasons, separated by a long and a short interval. The long dry season comes in our winter and spring months, and is known as the *verano*. The wet season (May to November) is known as the *invierno*. The short dry season (August) is called the *veranillo*, or *verano de Augosto*. The rainfall of the *invierno* comes as local thunderstorms, which occur regularly in the afternoon, and, at the height of the rainy season, may continue nearly all night.

Prof. Harrington has prepared a rainfall chart of Central America, from

which it appears, I., that the rainfall is greater on the Atlantic than on the Pacific side, as two or three to one; II., that the greatest rainfall is at Greytown, Nicaragua, the total annual fall being over 20 feet; III., that the next greatest precipitation is in Alta Verapaz, on the northern slopes of the mountains, and on the adjoining southern part of British Honduras; IV., that the smallest rainfall is along the upper plateaus in Central America proper, but on the southern coast in the Isthmus region.

There are four types of rainfall. The first is the typical *invierno* type, found along the Pacific slope and on the plateaus of moderate elevation, and distinguished by having a maximum in June and October, almost no precipitation from November to April, and a secondary minimum in August. The second type is found in the northeast; has maxima in June and October, but has its *invierno* extended to January. There is no absolutely dry month. The winter rainfall is not a thunderstorm rainfall, but shows no diurnal periodicity, being like the cyclonic precipitation of temperate latitudes. The third type of rainfall is found on the southern half of the Atlantic Coast; it has no dry month, and has maxima in July, November, and January. The fourth type is a transition type. Its *verano* is brief (January–March); the maxima are in April and November; the summer dry season is extended. This type is found in southern Central America, on the Isthmus of Panama.

The diurnal distribution of the rainfall at San José, Costa Rica, is clearly shown in a diagram, the rainfall at this station being of the typical *invierno* type. In October more than half the rain falls in the three hours from 3 to 6 P. M., and two thirds in the five hours from 1 to 6 P. M. The greatest hourly rainfall observed at San José is 1.9 inches, which gives a rate of 46 inches, or nearly 4 feet per day.

Weather Bureau Notes. — In a recent number of this JOURNAL (April, 1895, pages 452, 453) there was printed the first circular relating to the establishment of a department of sanitary climatology in the Weather Bureau. The Bureau has lately issued Circular No. 4, containing *Information Relative to the Investigation of the Influence of Climate on Health*, which gives further details of the work this department is to take up. Letters have been sent to the various officials of the Bureau throughout the United States, asking them to ascertain the methods of recording and reporting vital statistics in use in their respective localities, and the general plan to be pursued in the investigation of the subject of sanitary climatology has been outlined accordingly. The meteorological and climatic data will be furnished by the observers of the Weather Bureau, while the statistics of mortality and morbidity must come from the various local sanitary and medical authorities.

The present circular contains copies of the blank forms designed for use by Boards of Health and health officers in returning the deaths in their respective municipalities, districts, and States during any calendar week, and also of the blank form intended for the individual physician to use in reporting diseases which occur in his practice. These reports are to be sent to Washington weekly. "The vital and meteorologic statistics, having

been received, will be collated by general averages and by particular and selected events, as the comparison of the general mortality with the average conditions of the weather for the week, and the passage of storms and cold or hot waves, the appearance of epidemics, etc. Also, in instances as well-defined weather disturbances, comparisons of vital and meteorologic statistics will be made by daily periods. For example, a storm appearing in the western part of the country will be followed day by day as it passes eastward across the country, and the illness and deaths reported for these days from the localities traversed will be compiled and compared with the same kind of facts reported both before and after the storm. The same plan of treatment will be pursued in dealing with hot and cold waves. By these methods we may hope to be able to give, in time, definite information as to how much and how the accidental and constant variations of the weather affect the sick and well, and in what way the present forecasts and weather charts can be used in both curative and preventive medicine."

A monthly publication, devoted to sanitary climatology, is to be issued, containing tables, charts, and diagrams, together with brief statements of the general sanitary conditions of the different localities, especially as they may have been influenced by the weather.

The Weather Bureau has issued a *Circular of Information Relating to the Display of Wind Signals on the Great Lakes.* This circular explains the signals adopted and gives a full list of the Weather Bureau and wind-signal display stations on the Great Lakes, and of the places at which a copy of storm-warning messages is posted. Wind-signal displaymen on the Lakes are authorized to telegraph for information regarding expected weather conditions whenever this information is asked for by masters of vessels flying the American flag. When there is no Weather Bureau office or wind-signal display station at a port where his vessel happens to be, the master may himself telegraph for this information at Government expense.

New England Meteorological Society. — The thirty-seventh meeting of the New England Meteorological Society was held at the Massachusetts Institute of Technology, Boston, Saturday, May 4, 1895.

Mr. S. P. Fergusson gave an account of a meteorograph, designed at the request of Professor Pickering of the Harvard Observatory, for the mountain observatory on the volcano of El Misti in Peru. As two days are required to make the round trip from the base station to the summit, and as those who make the ascent are troubled with mountain-sickness, which sometimes lasts for one or two days after their return, it is important that an instrument that will run a considerable time should, if possible, be installed on the mountain. A single drum, driven by clock-work, is arranged to receive records of pressure, temperature, humidity, and direction and velocity of the wind, to run four months without attention. One of the chief difficulties in this instrument is to make sure of a steady tracing from the ink in the recording pens; but Mr. Fergusson thought that this was probably overcome. In order to protect the instrument from fine drifting snow — which is one of the chief embarrassments of mountain observatories — its mechanism is carefully enclosed in a case.

In the discussion that followed this paper, Mr. A. L. Rotch gave an account of the attempts that had been made to secure automatic records on mountain tops, describing particularly those of Vallot and Janssen on Mont Blanc. The meteorograph, constructed by Richard Frères, for Janssen, is said to have cost fifteen thousand francs, and to have been large and heavy; the one constructed by Mr. Fergusson, and exhibited to-day, costs a quarter or perhaps only one fifth of that sum, and is of much less size and weight. Mr. Rotch also gave a general account of the Harvard Observatories on Chachani and El Misti, the latter at a height of 19,300 feet. Although Whymper, the well-known mountain climber, has said that it was not likely that mules could be taken to heights over 16,000 feet, they had been used to carry materials and instruments up to the summit of El Misti. As the instruments constructed by Richard Frères for Janssen, to be set upon Mont Blanc, and by Fergusson for the Harvard Observatory, on El Misti, are both to be installed this year, it will be interesting hereafter to make some comparison of the results that they gain.

Mr. F. P. Gulliver gave an account of the electrical phenomena experienced during a dust storm in Colorado last October. In the latter part of a very hot day the air was filled with dust raised by a brisk wind. Mr. Gulliver, in attempting to open a gate in a wire fence, experienced a sharp electric shock. The fence extended some distance, enclosing a "small pasture of several square miles," and he was disposed to attribute the electric charge either to the action of the dust on the wire, or to induction from a thunder cloud that had passed at some distance away.

Mr. H. H. Clayton gave an account of the forms of clouds followed by rain, as determined by hourly observations at Blue Hill in 1887–88. Beginning with the first clouds that appeared after a time of cloudless sky, the changes of clouds until rain began were noted, and then followed in reverse order from the cessation of rain until the sky again became cloudless. The small fracto-cumulus clouds of diurnal convectional origin were not considered in the discussion. The most usual order of cloud succession was cirrus, cirro-stratus, alto-stratus, and nimbus, these forming a single sheet of clouds of diminishing altitude, but increasing thickness, from the first appearance of the cirrus edge to the beginning of rain. Two layers of clouds were less frequently seen before the rain, but were more common after the rain, when the succession of forms ordinarily observed was strato-cumulus below, and cirrus, or cirro-stratus above. Judging by the records of balloonists who have ascended through rain clouds, Mr. Clayton believed that the upper surface of the central nimbus was not so high as that of the cirrus clouds preceding and following the rain. The average time from the appearance of the first cirrus till rain began to fall was twenty-six hours; the average time from the last rain till the last cloud disappeared was eighteen hours.

The papers by Messrs. Fergusson, Gulliver, and Clayton will be published in the August number of this JOURNAL.

Mr. R. De C. Ward gave an account of a number of recent meteorological publications, and the secretary exhibited a copy of Rev. W. Clement Ley's recent book entitled "Cloud-Land," received by the Society as a gift from the author.

Royal Meteorological Society. — At the meeting of this society on Wednesday evening, April 17, which was held at the Surveyor's Institution, Westminster, Messrs. F. C. Bayard and W. Marriott communicated a paper on "The Frost of January and February, 1895, over the British Isles." The cold period, which commenced on Dec. 30 and terminated on March 5, was broken by a week's mild weather from Jan. 14 to 21, otherwise there would have been continuous frost for sixty-six days. Temperatures below 10° Fahrenheit and in some cases below zero, were recorded in parts of England and Scotland between Jan. 8 and 13, while from the 26th to the 31st, and from Feb. 5 to 20, temperatures below 10° occurred on every day in some part of the British Isles. The coldest days were Feb. 8 to the 10th. The lowest temperatures recorded were — 17° at Braemar, and — 11° at Buxton and Drumlanrig. The mean temperature of the British Isles for January was about 7°, and for February from 11° to 14° below the average, while the mean temperature for the period from Jan. 26 to Feb. 19 was from 11° to 20° below the average. The distribution of atmospheric pressure was almost entirely the reverse of the normal, the barometer being highest in the north and lowest in the south, the result being a continuance of strong northerly and easterly winds.

The effect of the cold on the public health was very great, especially on young children and old people. The number of deaths in London due to diseases of the respiratory organs rapidly increased from Feb. 2 to March 2, when the weekly number was 1,443, or 945 above the average. Rivers and lakes were frozen, the ice being more than ten inches thick.

The frost will long be remembered for its effect on the water pipes all over the country, in many cases householders being without water for more than nine weeks. As the result of inquiries, the authors find that mains have frozen which have been laid as low as 3 ft. 6 in. from the surface of the ground to the top of the pipe. It appears, however, that the nature of the soil had far more to do with the depth to which the frost penetrated than the intensity of the frost itself.

From a comparison of previous records the authors are of opinion that the recent frost was more severe than any since 1814.

Mr. Birt Acres also read a paper on "Some Hints on Photographing Clouds."

Scientific Balloon Ascents in September, 1894. — In the February-March number of the *Zeitschrift für Luftschiffahrt,* Dr. Berson has a note on the balloon ascents of last September. On Sept. 6, at a quarter before 9 A. M., the weather being fine, with practically no wind, and the temperature about 53.5°, the registering balloon "Cirrus," with self-registering instruments but no aeronaut, was let loose. It ascended with the velocity of an arrow and disappeared from view in a few minutes in an easterly direction. Four minutes later the balloon "Phönix" followed, with Dr. Berson and Herr Becker in its car, and five minutes after that the balloon "Majestic" was cast loose, with Lieut. Neumann, Mr. Alexander, and Dr. Süring as its passengers.

The "Phönix" moved very slowly towards the northwest, on a long curve; then to north, northeast, and east-northeast, above the suburbs of

Berlin. The "Majestic" met with a mishap, and landed in a short time in one of the northern suburbs of Berlin, having attained a height of only 1,100 meters. The movement of the "Phönix" was very slow for some time, and in one hour and seventeen minutes it had only travelled 15 kms. Between 2,500 and 3,200 meters the wind turned more to the southwest, and the movement became still slower, being about 11 kms. an hour only. This is a very unusually slow movement for a height of 3,000 meters. Above 3,200 ms. the rate of progression increased, and at 11.50 A. M. 4,000 ms. were reached. At this time massive cumulus clouds began to form, and the earth's surface could only be seen occasionally through the clouds. Between noon and 2 P. M. the balloon travelled 120 kms., and at 1.30 P. M. reached the greatest altitude, about 6,220 ms. The mercury barometer stood at 13.74 in. and the thermometer at — 14.8° Fahr. A few single cirrus clouds were observed at higher levels near the horizon, while below the balloon there was a chaos of massive cumuli. A landing was effected at 3.55 P. M.

The temperature of the air showed hardly any change up to 500 ms.; above that height a regular decrease was noted. Freezing point was reached at 1,900 ms. (6,233.6 ft.), the temperature at the earth's surface at this time being 57.20° Fahr. From 1,900 ms. to 3,100 ms. the temperature decreased fairly regularly to 17.6° Fahr. Above this point, at the level of the cumulus clouds, considerable irregularities appeared, and between 4,000 and 4,250 ms. over the cumuli there was an *increase* of temperature from 7.7° to 11.8° Fahr. In the upper strata there were also repeated interruptions in the regular decrease of temperature, and also inversions. The average decrease between 4,250 and 6,050 ms. was .8° C. per 100 ms., and that between the surface of the earth and 6,050 ms., at 1.30 P. M., was .73° C. per 100 ms.

The "Cirrus" traversed a distance of 900 kms. in six and three quarters hours, at an average rate of 37 meters per second. The lowest temperature registered was — 88.6° Fahr., and the lowest pressure was a little below 2.36 inches. Taking the temperature into consideration the greatest altitude reached by the "Cirrus" was about 18,450 meters, without doubt the maximum authenticated altitude ever attained by a balloon.

Temperatures Injurious to Food Products in Storage and During Transportation. — Bulletin 13, of the Weather Bureau, is entitled "Temperatures Injurious to Food Products in Storage and During Transportation, and Methods of Protection from the Same," and was prepared by Mr. H. E. Williams, Chief Clerk of the Forecast Division. The object of the bulletin is "to furnish information regarding the temperatures that are injurious to food products and other perishable articles, under different conditions and during shipment, and to suggest methods of protecting the same from extremes of heat and cold." The information on which the statements are based was secured, in reply to a circular letter, from merchants and shippers all over the country.

There is much in this report which will be of general interest. In connection with shipping fruit, for instance, it is stated that many of the precautions taken to keep out the cold will also keep in the heat, and often the danger from heating by decomposition is as great as, or greater than, that

arising from the cold. All fresh fruit tends to generate heat by the process of decomposition. A carload of fresh fruit, which is nearly ripe, and is closed up tightly in a refrigerator car not iced, with a temperature of over 50°, will generate sufficient heat in twenty-four hours to injure the fruit, and, in two or three days, to cook it as thoroughly as if it had been subjected to steam heat. For this reason the heat generated inside the car must be provided against, as well as the heat or cold outside.

The last section of the Bulletin deals with the "Use of the Weather Reports in Connection with the Safe Storage and Shipment of Food Products," and calls attention to the great advantages to be gained from a knowledge of the temperature distribution in different sections of the country and of the coming weather conditions. Shipments are expedited or delayed according to the favorable or unfavorable conditions of weather and temperature in the districts through which they are to pass, and shipments already on the road are protected by telegraphic instructions. The question of whether to use water or rail in sending food products from the South to the North is often settled by reference to the weather conditions which are coming. Dealers also judge of the probable supply of different kinds of fruit and vegetables by observation of the crop bulletins and daily weather reports, and they can thus find out where to purchase with advantage.

Annual Report of the Berlin Branch of the German Meteorological Society. — The Annual Report of the Berlin Branch of the German Meteorological Society calls attention to the fact that ten years have elapsed since the foundation of the Berlin society, and, although the scientific work done is of such a character that it only appeals to a limited number of persons, yet the membership continues to hold its own very well. Among the papers read during the year the following may be mentioned: Dr. von Bezold, on "Cloud Formation" (a translation of which was printed in this JOURNAL, Vol. XI., pages 157–175); Dr. Schubert, "Investigation into the Climatic Importance of Forests"; Prof. Dr. Sprung on "The Wind Velocities observed on the Eiffel Tower"; Dr. Kassner on "A Possible Relation between Cloud Waves and Precipitation"; Dr. Hellmann, "The Two Hundred and Fiftieth Jubilee of the Barometer."

An appendix to the report, by Dr. G. Hellmann, deals with "The Velocity of the Wind in Berlin." The data on which this investigation is based are the anemometer records during the years 1884–1894. The average velocity, in meters per second, is 5.1 for the year. March has the principal maximum of wind velocity and September the minimum. If a stormy day is considered to be one on which the wind velocity is at least sixteen meters per second during one hour or longer, then March and January are seen to be the stormiest months. The maximum mean hourly velocity was 22.5 meters per second on March 5, 1891, but higher velocities in shorter periods than one hour occur frequently, as in squalls and summer thunderstorms. The maximum daily velocity comes between 1 and 2 P.M. throughout nearly the whole year, and a tendency towards a secondary maximum is found in the late evening and night hours during the winter. The cause of the latter phenomenon Dr. Hellmann believes to be the high position of the anemometer.

Third Biennial Report of the Oregon Weather Bureau. — The Third Biennial Report of the Oregon Weather Bureau, prepared by Mr. B. S. Pague, Local Forecast Official and Director of the Oregon Weather Service, has been issued. It is a publication of great value from a meteorologic and a climatic standpoint, and fully maintains the high standard of excellence attained in the previous volumes issued by the same Service. The present Report contains papers on "Weather Forecasting," illustrated by two weather maps; "Irrigation in Oregon"; the "Soils of Oregon," by G. W. Shaw, Chemist of the Oregon Agricultural College; "Cereal Production of Oregon"; the "Climate of Portland." The principal paper is one on the "Climate of Oregon," which is based on the latest meteorological records, and is very complete. It contains many tables, giving the various data of climatic importance, and sections on the geography and topography, the oceanic and mountain influences on the climate, the products, etc.

The Report also contains the usual tabular statement showing the temperature, precipitation, and character of the weather in Oregon from all available sources.

Italian Meteorological Society. — The Italian Meteorological Society, which was threatened with dissolution at the death of Father Denza, its founder, has decided to continue its existence under the temporary presidency of a Council, composed of the following gentlemen: Antonio Cittadella Vigodarzere, Guido Cora, and Almerico Da Schio. This Council is to direct the affairs of the Society until the meeting of the General Assembly.

Terrestrial Physics at the University of Chicago. — The University of Chicago has decided to add Terrestrial Physics to the subjects taught in the Physical Department, under Prof. Michelson. Prof. Michelson has secured Dr. L. A. Bauer to give courses in terrestrial magnetism, thermodynamics of the atmosphere, and dynamic meteorology. Dr. Bauer begins his lectures July 1st. This step on the part of the University of Chicago marks a new era in the development of the study of meteorology in the United States.

BIBLIOGRAPHICAL NOTES.

DAILY WEATHER MAPS FOR 1894.

THE following daily weather maps for the year 1894 have been received in the library of the United States Weather Bureau. The area covered by each map is indicated in parentheses.

Austria. Telegraphischer Wetterbericht, K. K. Centralanstalt für Meteorologie. Wien. (Europe.) 18th year of publication.

Algeria. Bulletin météorologique de l'Algérie. (Europe and northern Africa.) 19th year of publication.

Belgium. Bulletin météorologique. Observatoire Royal de Belgique. Bruxelles. (Southern, western, and northern Europe.) 18th year of publication.

France. Bulletin international du Bureau Central Météorologique de France. Paris. (Europe.) 38th year of publication.

Germany. Wetterbericht. Deutsche Seewarte. Hamburg. (Europe.) 19th year of publication.

Germany. Wetterkarte und Wetterbericht der K. Bayer. Meteorologische Centralstation, München. (Europe.) 14th year of publication.

India. Indian daily weather report. Simla, Meteorological Office. (India and Burma.) 16th year of publication.

Italy. Bollettino Meteorico dell' Ufficio Centrale di Meteorologia e di Geodinamica. Roma. (Southern Europe.) 16th year of publication.

Japan. Weather map (Tridaily). Central Meteorological Observatory, Tokio. (Japan.) 12th year of publication.

Russia. Bulletin météorologique de l'Observatoire Physique Central. St. Pétersbourg. (Europe.) 23d year of publication.

Spain. Boletin del Instituto Central Meteorológico. Madrid. (Spain, France, and northern Italy.) 2d year of publication.

Switzerland. Wetterbericht der Schweizerischen Meteorologischen Centralanstalt in Zürich. (Europe.) 14th year of publication.

United States. Weather map (semi-daily). United States Weather Bureau, Washington, D. C. (United States and southern Canada.) 24th year of publication.

Published but not yet received in the library of the Weather Bureau.

Great Britain. Daily weather reports. Meteorological Office, London. (British Isles and western Europe.) 27th year of publication.

Saxony. Wetterbericht des K. Sächsischen Meteorologischen Instituts in Chemnitz. 17th year of publication.

TITLES OF RECENT PUBLICATIONS.

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU, WASHINGTON, D. C.

(An asterisk [*] indicates that the publications thus designated have been received by the Editor of this JOURNAL.)

*BATAVIA. *Rainfall in the East Indian Archipelago.* Fifteenth year, 1893. 8vo. Batavia, 1894. xii, 416 pp.

CHALLENGER EXPEDITION. *Report on the scientific results of the voyage of H. M. S. Challenger, during the years* 1872–76. Appendix (*Physics and Chemistry,* Part VIII.). *Report on oceanic circulation.* By Alex. Buchan. 4to. London, 1895. vii., 38 pp. 16 maps.

FALB, RUDOLPH. *Kritische Tage, Sinfluth und Eiszeit.* 12mo. Wien, Pest, Leipzig. viii, 163 pp.

FORSTER, ADOLF E. *Die Temperatur fliessender Gewaesser Mitteleuropas.* (Penck's Geogr. Abhandl. Bd. V. Heft 4.) 8vo. Wien, 1894. 95 pp. 1 pl.

*GAUSS, CARL FRIEDRICH. *Die Intensitaet der Erdmagnetischen Kraft auf Absolutes Maas zuruckgeführt.* (1832.) Herausgegeben von E. Dorn. (Ostwald's Klassiker der exakten Wissenschaften. Nr. 53.) 12mo. Leipzig. 1894. 62 pp.

GENOVA. REGIA UNIVERSITA. OSSERVATORIO METEOROLOGICO. *Stato meteorologico e magnetico di Genova per l'anno* 1893. Anno LXI. 4to. (Genova, n. d.) 39 pp.

*HARRINGTON, M. W. *Central American Rainfall.* Extr. from Bull. Phil. Soc., Washington. Vol. XIII. pp. 1–30. 4 pls.

HONGKONG OBSERVATORY. *China coast meteorological register.* Jan. 1 to Dec. 31, 1894. (Issued daily.) 8vo. Hongkong, 1894. Single sheets.

KAMINSKIJ, A. *Der jährliche Gang und die Vertheilung der Feuchtigkeit der Luft in Russland nach den Beobachtungen von* 1871–1890. (Sechster Supplementband zum Repertorium für Meteorologie, hrsg. von der Akad. der Wissenschaften.) 4to. St. Petersburg, 1894. 625 pp. 11 ch.

KREBS, WILHELM. *Atmosphaerische Pracht und Kraftentfaltung.* Zwei Essays. I. *Die Regenbogen und ihre Theorie.* II. *Luftwogen und Luftschiffahrt.* (Sammlung gemeinverstaendlicher wissenschaftlicher Vortraege. Neue Folge ix. Heft 200.) 12mo. Hamburg, 1894. 38 pp. ill.

*LANCASTER, A. *Le climat de la Belgique en* 1894. 12mo. Bruxelles, 1895. 181 pp. 2 pl.

*LONDON METEOROLOGICAL OFFICE. *Report of the Meteorological Council to the Royal Society for the year ending 31st of March,* 1894. 8vo. London, 1894. 102 pp. 1 ch.

MCADIE, ALEXANDER. *New cloud classifications.* Extr. from Bull. Phil. Soc., Washington. Vol. XIII. pp. 77–86.

MARCHI, LUIGI DE. *Le cause dell' era glaciale. Ricerca teorica delle condizioni che determinano l'attuale distribuzione delle temperature e delle pioggie sulla superficie terrestre e che possono averla modificata nei precedenti periodi geologici.* 8vo. Pavia, 1895. xii, 231 pp. 1 pl.

MÜHLAN, DR. A. *Grundriss der Physik und Meteorologie. Ein Leitfaden für Fortbildungs-, Mittel-, Bürger- und Toechterschulen, sowie auch landwirthschaftl. Lehranstalten.* 12mo. Leipzig, 1894. viii, 90 pp. ill.

PFEIL, L. GRAF. *Temperaturveraenderungen auf der Erdoberflaeche.* Zweite vermehrte Auflage. 8vo. Leipzig, 1894. 39 pp.

*PORT AU PRINCE (HAITI). *Taeglicher Gang des Barometers zu Port au Prince nach zweijaehrigen Beobachtungen* 1890–92 *des Herrn Prof. P. Josef Scherer, nebst einer Uebersicht der bisherigen Beobachtungsergebnisse zu Port au Prince* 1865–69 *von Prof. A. Ackermann und* 1888–1893 *von Prof. J. Scherer.* Extr. from Jahrb. K. K. Central-Anstalt für Meteorol. Wien, 1893. 4to. 16 pp.

REPERTORIUM FÜR METEOROLOGIE. Hrsg. von der K. Akad der Wissenschaften. Red. von. Dr. Heinrich Wild. Band XVII. 4to. St. Petersburg, 1894.

CONTENTS.

No. 1. E. LEYST. *Ueber den Magnetismus der Planaten.* 118 pp. 2 pls.

No. 2. E. HEINTZ. *Ueber Niederschlagsschwankungen im Europaeischen Russland.* 25 pp. 2 pls.

No. 3. F. MÜLLER. *Barometer-Nivellement zwischen Irkutsk und dem Eismeer.* 19 pp. 1 ch.

No. 4. B. KIERNOWSKY. *Untersuchung gleichzeitiger Regen im Gebiete St. Petersburg-Pawlowsk.* 19 pp.

No. 5. I. SCHUKEWITSCH. *Actinometrische Beobachtungen im Konstantinow'schen Observatorium zu Pawlowsk.* 60 pp. 1 pl.

No. 6. H. WILD. *Beitraege zur Entwickelung der erdmagnetischen Beobachtungsinstrumente.* 31 pp. 2 pls.

No. 7. A. BEYER. *Die Gewitter Russlands im Jahr* 1887. 33 pp. 1 pl.

No. 8. E. HEINTZ. *Die Gewitter Russlands im Jahr* 1888. 44 pp. 2 pls.

No. 9. E. BERG. *Ueber die Schneegestoeber im Europaeischen Russland im Winter* 1891 *auf* 1892. 25 pp.

No. 10. O. BRITZKE. *Der jaehrliche Gang der Verdunstung in Russland.* 54 pp. 1 pl.

No. 11. J. MIELBERG. *Die magnetische Declination in Tiflis.* 41 pp. 1 pl.

No. 12. S. SAWINOW. *Die Stürme des Kaspischen Meeres.* 78 pp. 2 pls.

No. 13. W. DUBINSKY. *Magnetische Messungen in den Ostsee-Provinzen und im Weichselgebiet im Sommer* 1893. 29 pp. 4 pls.

No. 14. H. WILD. *Jahresbericht des physikalischen Central Observatoriums für* 1893. 73 pp.

ST. PETERSBURG. PHYSIKALISCHES CENTRAL-OBSERVATORIUM. ANNALEN. Hrsg. von H. Wild. Jahrgang 1893. Theil I. *Meteorologische und magnetische Beobachtungen von Stationen I. Ordnung und ausserordentliche Beobachtungen von Stationen* 2 *und* 3. *Ordnung.* 4to. St. Petersburg, 1894. 584 pp. Theil II. *Meteorologische Beobachtungen der Stationen* 2. *Ordnung in Russland nach dem internationalen Schema.* 4to. St. Petersburg, 1894. 699 pp.

*San Salvador. Observatorio Astronómico y Meteorológico. Dr. Alberto Sanchez, Director. Contents: *Description of the Observatory; catalogue of the library; list of correspondents; monthly meteorological observations for the year* 1893; *publications received from July to December*, 1894. 4to. San Salvador. 1895. 65 pp.

Sohncke, Leonhard. *Gewitterstudien auf Grund von Ballonfahrten.* (Extr. from Abhandl. K. bayer. Akad. der Wissenschaftten., II., Cl. XVIII. Bd. III. Abth.) 4to. München, 1894. 60 pp.

Switzerland. Schweiz. Meteor. Centralanstalt. *Meteorologische Beobachtungen an* 12 *Stationen der Schweiz.* I. Semester, 1894. Jan.–Juni. 4to. Zurich. 72 pp.

Trieste. Osservatorio Astronomico-Meteorologico. *Rapporto annuale contente le osservazioni meteorologiche di Trieste e di alcune altre stazioni Adriatiche per l'anno* 1892. Redatto da Edvardo Mazelle. IX. volume. 4to. Trieste, 1895. 114 pp.

U. S. Engineer Corps. *Report of Board of Engineer Officers as to maximum span practicable for suspension bridges.* Major Chas. W. Raymond, Capt. Wm. H. Bixby, Capt. Edward Burr, Members of the Board. 8vo. Washington, 1894. 109 pp. 2 pls. (Appendix C, pp. 37–68. *Wind Pressures: History of past experiments and application to bridges.*)

*U. S. Weather Bureau. *Information relative to the investigation of the influence of climate on health.* Circular No. 4. Sanitary Climatology. 8vo. Washington, March, 1895. 7 pp.

*U. S. Weather Bureau. *Report on the condensation of atmospheric moisture.* By Carl Barus. Bulletin No. 12. 8vo. Wash., 1895. 104 pp. 4 pl.

*U. S. Weather Bureau. *Circular of information relating to the display of wind signals on the Great Lakes.* 8vo. Washington, 1895. 13 pp.

Upsala L'Université. *Bulletin mensuel de l'Observatoire Météorologique de l'Université d'Upsal.* Vol. XXVI. Année 1894. Par Dr. H. Hildebrand-Hildebrandsson. (Hourly values.) Fol. Upsal, 1894–95. 74 pp.

Williams, Charles Theodore. *Aero-therapeutics, or the treatment of lung diseases by climate. With an address on the high altitudes of Colorado.* 8vo. London, 1894. xii, 187 pp.